A DELPHI STUDY ON THE CRITICAL SUSTAINABILITY CRITERIA AND INDICATORS FOR AUSTRALIAN ROAD INFRASTRUCTURE PROJECTS

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Abstract

With increasing media exposure and evidence of environmental impacts, it is increasingly recognized that incorporating sustainability principles in construction works is both crucial and beneficial. However a recent survey reveals that among stakeholders of infrastructure projects such as roads, there is no common understanding on what constitutes sustainability in real-life projects. Sustainability has been interpreted widely and differently and as a result, sustainability outcomes are not tangible at the project level or often neglected. Under such conditions, policies and strategies on sustainability remain largely ideological and cannot be sufficiently reflected in the actual project delivery. The major difficulty of this sustainability pursuit lies in the lack of consensus among the experts on sustainability criteria and indicators. To move ahead, these criteria and indicators are to be agreed upon.

This paper reviews the sustainable infrastructure development, its criteria and indicators, focusing on road infrastructure context. It goes on to introduce a Delphi study, an integral part of a QUT research, aimed at identifying critical sustainability criteria and indicators for Australian road infrastructure projects. It paves the way for further identification of solutions for each critical indicator at a subsequent stage. The criteria, indicators and solutions will be encapsulated into a decision making framework for the enhancement of sustainability deliverables. By doing so, the research will promote more integrated thinking of and consistent approaches to the sustainability agenda in road and highway infrastructure projects in Australia.

1. Introduction

Business-as-usual can no longer be tolerated given the mounting detrimental pressure the mother earth is bearing, especially environment. In its chain effect, the environmental calamities caused by unsustainable human activities also impact on economy and society as a whole. While we continue enjoy the so-called economic prosperity, the ground of disastrous impact is swelling with each passing day. Therefore, sustainability is a vital concern for the long-term development of human society and ecosystem.

Sustainability does not mean stopping all activities but rather 'doing it right' now by constantly aligning ourselves with the thought for future generations. Sustainability calls for *"development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs"*

Despite an increasing level of highlight on sustainability agenda worldwide, the response from construction industry was far from encouraging. This alarming response causes serious concern as built environment particularly the infrastructure accounts for huge consumption of resources on earth. A recent research on construction companies' attitudes to sustainability in United Kingdom found that very few companies positively embrace sustainable ideas (Myers, 2005), or different companies have described different individual and organizational perceptions and definitions of sustainability (Shelbourne, et. al, 2006). The research further revealed that the fragmented and diverse nature of the industry is the main reason for such scenario. Worst still, it is beset with an adversarial culture (Chan, et al., 2005). At any given project, construction stakeholders have their own concerns, priorities and interests, resulting different expectations in the project delivery. Often the disciplines are unwilling or unable to consider the views represented by others

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because there is not a common language place (Lombardi & Brandon, 1997). In the absence of common understanding among these stakeholders, achieving sustainability outcomes remains as a formidable task.

Under such conditions, policies and strategies on sustainability remain largely ideological and cannot be sufficiently reflected in the actual project delivery. The major difficulty of this sustainability pursuit lies in the lack of consensus among the experts on sustainability criteria and indicators. To move ahead, these criteria and indicators are to be agreed upon.

2. Australian Road Infrastructure and Sustainable Development

For Australian road infrastructure, it has been under constant scrutiny for not being able to sufficiently cater for its rising demand. A few scenarios that attributed to this infrastructure bottleneck are strong economic growth with surge in resource export, political stability that attracts substantial foreign investments and increased population, coupled with improved living standards and growing societal expectations.

Infrastructure Partnerships Australia (2007) envisaged that the land freight task is projected to double by 2020 and critical linkages such as the Pacific Highway between Sydney and Brisbane is under-developed, and the Hume Highway linking Sydney and Melbourne, in many sections, a two lane road. Besides, Australia has a strong motorcar culture that further strains the nerve of road infrastructure. The geographical widespread and decentralized nature of development means more roads are needed to commute from one place to another. Additionally, many urban roads are old and in need of repair. The fast pace of economic growth is placing immense pressure on government to repair, upgrade and build new infrastructures in order to set free development bottlenecks to allow further growth.

In response to the massive road infrastructure needs, the government is spending billions of dollars, and conduct regulatory reforms to speed up the planning, development and delivery of major road works. For example, in Queensland, it is reported that the state government will invest over AUD$ 82 billion in the next 20 years under an ambitious infrastructure program; road, rail and public transport infrastructure tops the list which accounts for over 60% of the total investment (Queensland Government, 2007). During the 2008/09 budget, the Australian federal government has also a $20 billon expenditure on developing new and improving existing infrastructure nationwide.

While governments' initiatives set important directions, the challenge lies in the ability for infrastructure stakeholders to actively take into account environmental and social sustainability, while meeting the financial accountability and challenges in moving towards road infrastructure sustainability (Figure 1). Naturally one of these elements may require additional attention from time to time to ensure that balance is achieved; persistent favoring of one element over the others is not sustainable development (Engineers Australia, 2005).

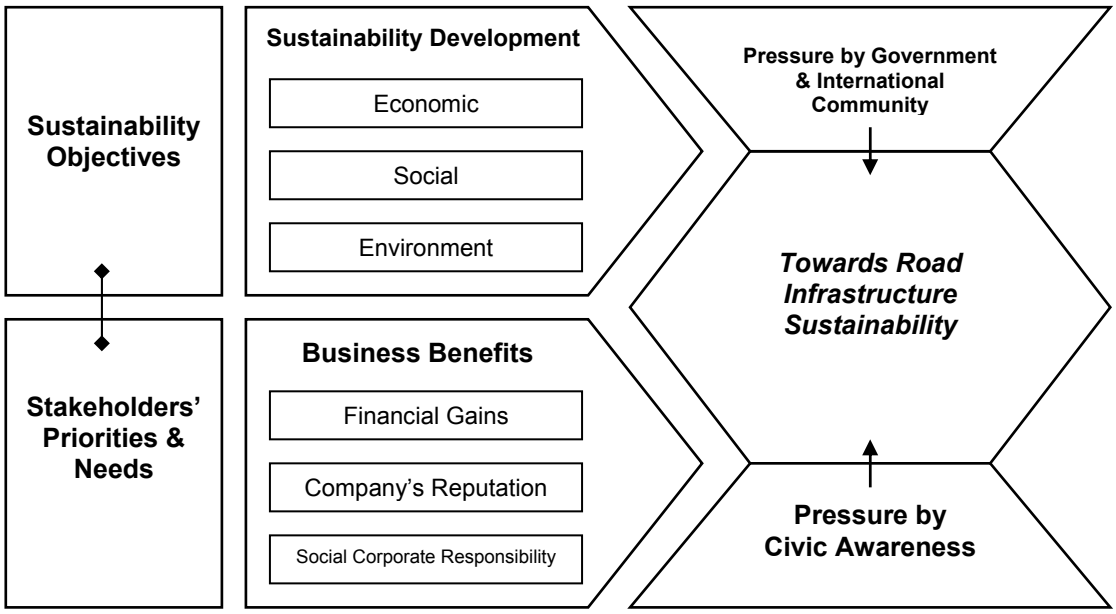


Figure 1: Meshing Stakeholders' Expectations & Sustainability Objectives Towards Achieving Sustainable Road Infrastructure Development

The fact that each stakeholder is driven by their own interests, their perceptions on what constitutes sustainable road infrastructure development vary accordingly. Often, they perceive from their own point of benefits and priorities. Therefore, understanding the stakeholders' needs and various perceptions on sustainability becomes crucial. This can be achieved through systematic identification on their project priorities as well consensus on sustainability criteria and indicators for sustainable road infrastructure projects. In doing so, it will help meet the sustainability goals, and at the same time satisfying the needs of those stakeholders.

3. Criteria and Indicators for Sustainable Road Infrastructure Projects

Sustainability is a broad and subjective concept. To measure sustainability, therefore, indicators that can rightfully represent the sustainability of a development process are required. However, such indicators must be able to reflect a holistic aspect of sustainability rather than being too narrowly confined to few areas of focus. While specific indicators are required, criteria covering a relatively wide area of concern are equally imperative to yield a meaningful sustainability measurement (Figure 2). This, however, should not be rigid but inclusive to take into account a particular or localized context.

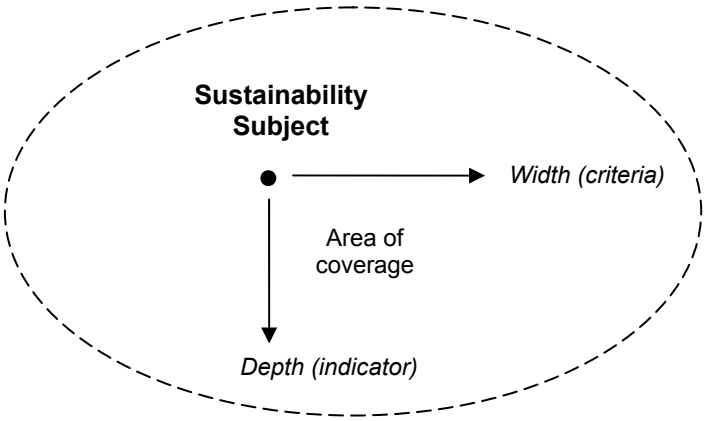


Figure 2: Sustainability Criteria and Indicators Coverage Area

Engineer Australia (2005) outlined that an infrastructure is sustainable if it meets the environment, social and economic sustainability. However, Sahely et al. (2005) proposed set of criteria and generic sub-criteria for sustainable infrastructure systems based on *Triple Bottom Line (TBL)*, with an addition of engineering criteria that pertinent to infrastructure project undertakings. In a recent research of identifying Key Performance Indicators (KPI) for infrastructure in South Africa construction industry, Ugwu and Haupt (2005) have developed a comprehensive list of key sustainability items and its indicators. Besides TBL, as suggested by the industry, it also incorporated other performance-based indicators such as health and safety (eg. occupational and public), resource utilization (eg. site access and material availability) and aspects related to project management (eg. contract and procurement method).

Though there were some initial attempts in developing sustainability indicators for infrastructure in general, literature review found that little has been done specially on road infrastructure. This is crucial as road infrastructure extends over large geographical spaces, have much wider impact and more varied potential impacts. In an effort to rectify this shortcoming, a research project is being conducted at QUT to establish a list of road infrastructure sustainability criteria and indicators – an integral part to developing integrated decision-making guidelines for the improvement of sustainability deliverables in road projects as the final outcome of the research.

The project began by interviewing 20 targeted senior representatives within the collaborating infrastructure stakeholders in Queensland, Australia. Many have the experience of working with all professions represented in this group and even with each other (businesses) as partners of major consortiums for large projects in Queensland, interstate and in some cases, overseas. They comprise of government departments, financier/banks, environmentalists, community consultants, contractor/builders, designers, engineers, project managers, town planners and cultural heritage experts. Collectively, these high-ranking professionals possess a wealth of experience in a diverse range of infrastructure projects such as roads and highways, rails, seaports, airports and dams. However, the interview was specific on road infrastructure development.

Literature studies have helped the compilation of over 16 criteria/categories and 250 sustainability indicators overall. This long list reduced to 10 sustainability priorities and around 106 indicators through the interviews

as the most appropriate and applicable under local conditions in general. While four were the so-called traditional sustainability components (institutional, environment, economic, and social and cultural), six were road infrastructure project specific components (resource utilization and management, health and safety, project management, relationship management, public governance and community engagement, and engineering issues). To obtain measurable outcomes, each component was categorically broken into related indicators which represent issues to be addressed in order to achieve sustainability deliverables in road infrastructure projects. The triangulation of interview results provided an overall picture of sustainability in relation to roads infrastructure development in Australia.

4. Seeking Consensus on Critical Sustainability Indicators through Delphi Method

As discussed above, the literature review has identified that there is a lack of consensus among the various stakeholders in construction projects on the perceptions and expectations towards achieving sustainability and the criteria used to access sustainability. Due to such differences, in this case, infrastructure sustainability indicators vary accordingly. To overcome these deficiencies, the Delphi technique provides a good measure.

The objective of most Delphi applications is the reliable and creative exploration of ideas or the production of suitable information for decision-making (Gunaydin, 2007). It is a method of generating ideas and facilitating consensus among a group of experts who do not meet and who may be geographically distant (Polit and Beck, 2004). The fundamental philosophical assumption of this method is that '*n* heads are better than one' (Dalky, 1972). The highly structured and formalized nature of communication in Delphi to extract unbiased opinions and ultimately, consensus among a group of experts has made the method increasingly popular and widely used in technology, education and other fields.

Since the panel comprises of experts who normally have tight daily schedule, it becomes immediately apparent that attempting to gather all of these people in one place at the same time represents a logistical nightmare. Therefore, one immediately apparent advantage of the Delphi method was that it allows for dialogue and discourse among participants to occur without requiring face-to-face contact (Jenkins, 1996). Furthermore, the anonymity of respondents in Delphi process will allow individuals to respond without fear and pressure which might otherwise be associated with a traditional group setting where individuals receive immediate and direct feedback (Dalkey, 1972). In other words, the method will facilitate frank and genuine 'group' discussion on a specialized area (i.e infrastructure sustainability) without experts actually and necessarily being together.

Besides, in addition to allowing for individual input and controlled opinion feedback, the Delphi method affords each participant time to consider his or her response in ways that might not have been possible in group decision-making meetings (Jenkins, 1996). Similarly, the method also allows the researcher time to manage the returns from participants (as opposed to trying to moderate a group discussion/meeting), while also providing feedback in the form of responses and analysis (Brown et al., 1969). Other major advantages include low cost, versatile application to any area where "experts" can be found, ease of administration, minimal time and effort for the director and panelists, and the simplicity, popularity and directness of the method (Sackman, 1975).

However, it should be noted from the outset that the Delphi method is not an approach aimed at identifying "truth" regarding a particular topic or problem (Scheele, 1975). Rather, this approach attempts to negotiate a reality that can be useful in moving a particular field forward, planning for future, or even changing the future by forecasting its events. Hence, rather than attempting to define the ultimate truth regarding road infrastructure sustainability theory and practice, this Delphi study is more concerned with the long-term goal of the application of useful knowledge in this area. In other words, it is intended that a knowledge base regarding the theory and practice of road infrastructure sustainability first be identified and articulated, and later the application of this knowledge, following further investigation and empirical verification of the knowledge base at a later stage.

More specifically, the Delphi method will be used in this study in accordance with the observations of Helmer (1967), who noted that it has an important use in model building. Thus, it is used in an area (i.e infrastructure sustainability) where there remains an absence of an accepted theoretical body of knowledge (Prieto, 1996) to a point of particular decision and practical application. The lack of existing knowledge as well as common understanding among project stakeholders on sustainability issues has called for the need to fill this gap and establish a decision-making model in order to enhance sustainability deliverables in infrastructure projects.

Literature revealed that there were studies showing the use of such method in other construction related areas such as selection of procurement systems (Chan et al., 2001), re-lifing of commercial buildings (Yang

and Lim, 2007), development of residential areas (Anatharajan and Anataraman, 1982), theory and design application (Corotis et al., 1981), and bridge condition rating and effects of improvements (Saito and Sinha, 1991). But the use of Delphi method is new in the area of infrastructure sustainability. Though Delphi technique has been proven as a useful way and valid tool to identify opinions on certain issues among experts in the field, till date, such method has not been adopted to identify critical indicators/issues and seek consensus among experts in the area of road infrastructure sustainability.

5. The Delphi Study at QUT

Based on the 10 road sustainability priorities and 106 indicators identified previously through interviews, the purpose of this Delphi study is two-fold:

1. To refine the list of general indicators to critical road sustainability indicators, and
2. To seek consensus on those critical road sustainability indicators.

Careful selection of the panel by large will determine the success of Delphi method. A group of experts will be selected to provide opinions on the critical sustainability criteria and indicators for Australian road infrastructure projects. Since the information solicited requires in-depth knowledge and substantial experience on road infrastructure industry, a purposive approach is to be adopted to select this focused group of experts (Edmunds, 1999). The following criteria are used to correctly identify eligible participants for the Delphi surveys:

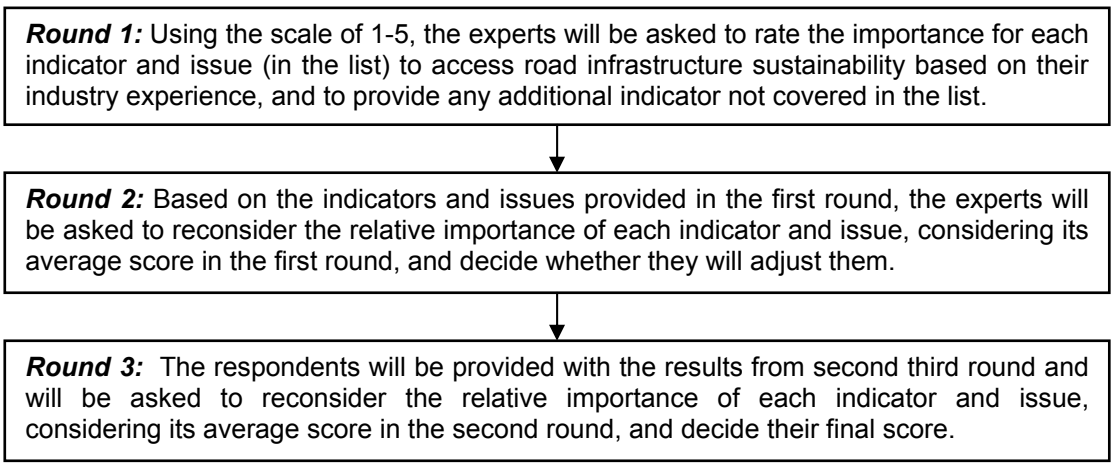
1. Established practitioners/stakeholders who are considered knowledgeable by the roads infrastructure industry and have extensive working experience in road projects in Australia.

2. Experts to be currently, recently or directly involved in the road infrastructure projects with sustainability focus.

3. Experts who are in decision-making roles in organizations or companies associated with road infrastructure projects;

In order to obtain the most valuable opinions, only practitioners/stakeholders who meet all the sampling criteria will be selected to sit in the panel of experts. Hasson et al. (2000) recommended that at least 15 experts be included in a Delphi study. On the other hand, Delphi experts agree that little is gained when panel size exceeds 30 panelists (Wilhelm, 2001). To ensure sufficient number of respondents for a valid data gathering is achieved, however, 25 experts have been identified and invited to participate in the Delphi. They comprise of government departments, financier/banks, environmentalists, community consultants, contractor/builders, designers, engineers, project managers, town planners and cultural heritage experts.

Although no standard number of iterations is completed in a Delphi study, three or four iterations are common (Murry and Hammons, 1995). Normally it is characterized by four distinct phases; (1) exploring, (2) reaching understanding, (3) resolving disagreements, and (4) confirming results. Nevertheless, a Delphi technique may be modified to suit a particular research question (Dinnebeil et al., 2006). For this research, the following stages are to be carried out:



The outcome of a Delphi sequence is nothing but opinion (Gunaydin, 2007). As such, the results of the sequence are only as valid as the opinions of the experts who made up the panel of this study. In addition, the results derived from Delphi study are not stand-alone rather it will be used for further investigation at a later stage, involving case studies and supported by semi-structured interviews.

The list of critical sustainability indicators and critical issues to be identified through Delphi study will reflect the consensual opinions of a group of experts on the theory and practice of road infrastructure sustainability. It does not, however, represent a final or an exhaustive list of road infrastructure sustainability indicators and its critical issues. Rather, the list serves as a basis for finding solutions in a defined context.
As discussed above, one of the purposes of adopting the Delphi technique is to aid in the building of practice models. In the case of study presented here, the method will be employed to gather and refine opinions of experts regarding the theory and practice of road infrastructure sustainability. It is expected that arriving at a specified level of consensus will allow for the establishment of a decision-making process model for sustainable infrastructure projects, and ultimately lead to the guidelines formulation as the final outcome of the research.

6. Conclusion

While sustainability is accepted as crucial and beneficial, the lack of understanding as well consensus on sustainability criteria and indicators proved to be a major obstacle in advancing the sustainability pursuit. This appears to be much more challenging in case of infrastructure such as roads where multiple stakeholders and huge mechanisms are involved in its development processes. In an attempt to fill this gap, a Delphi study is being conducted at QUT to gather consensus from among the experts in Australia on critical road sustainability criteria and indicators. The dynamic approach of Delphi method provides the distinctive advantage of combining both quantitative and qualitative procedures as the study is seeking to add to the process of theory and practice model building that ultimately leads to the formulation of integrated decision-making guidelines for enhancing sustainable deliverables during the implementation of sustainability strategies and foci in road infrastructure project delivery processes.

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